Communication of Robot Status to Improve Human-Robot Collaboration

Completed Technology Project (2015 - 2018)

Project Introduction

Future space exploration will require humans and robots to collaborate to perform all the necessary tasks. Current robots mostly operate separately from humans due to their limited capabilities. However, as robots become more capable and autonomous, further collaboration can occur. We identify two types of collaborations in the future: indirect, where the robot performs tasks separate the astronaut and direct, where the astronaut and robot work together in parallel. However, for either types of collaboration, the astronaut and robot must be able to coordinate their actions. This requires that the robot express information about its state, such as its intent and status. The cues that humans use to convey this information requires modalities of expression that many robots possess. Thus, our goal in this work is to find ways for robots to express their status using limited modalities. In our proposed work, we outline the steps. In the first step, we will use a needs finding approach to get a better understanding of the interactions that occur between astronauts and robots during space missions and to identify status relevant to successful collaboration. Next, we will explore different methods of conveying status using primarily three modalities: sounds, motion and lights. We choose these modalities because they are commonly available (or can be added) to most robot platforms. We will utilize techniques from animation, human-computer interaction and psychology and validate our work in user studies on several proposed platforms (Sphero, VGo, Quadrotor). The platform we are targeting is the new free-flying robot in development at the Intelligent Robotics lab at Ames. Lastly, we will validate our work in a small study with our target population, astronauts. Since, astronauts are not easily accessible, we will first utilize mission control and a convenience population to gather data and validate our work. It is important, however, to test our work with our intended users in a smaller study. NASA has shown an ongoing interest in having robots both autonomous and teleoperated on the International Space Station. With astronaut time highly limited, it is necessary to utilize all tools at hand to relieve their workload to improve mission success. This work is directly applicable to NASA's current system, the Smart SPHERES, as well as its new system, the free-flying robot. Furthermore, this work can help inform the design of the new free-flying robot such that human-robot collaboration can be improved in future space missions.

Anticipated Benefits

This work is directly applicable to NASA's current system, the Smart SPHERES, as well as its new system, the free-flying robot. Furthermore, this work can help inform the design of the new free-flying robot such that human-robot collaboration can be improved in future space missions.

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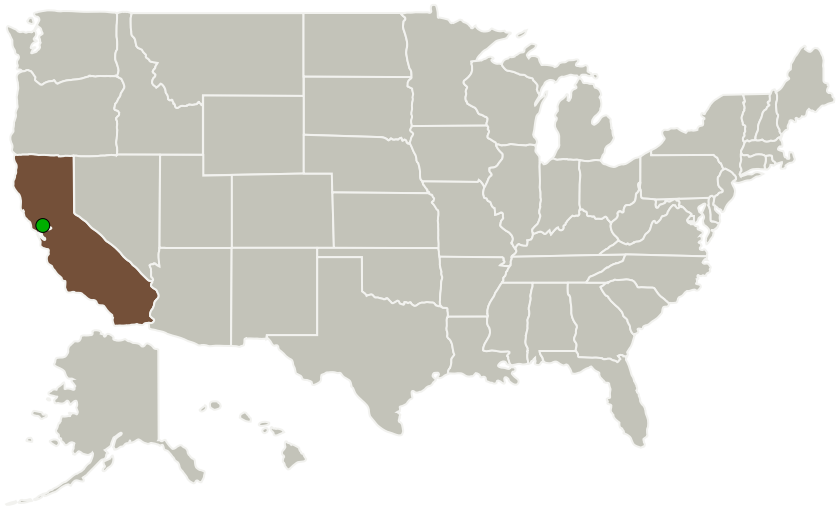
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
University of Southern California(USC)	Lead Organization	Academia Asian American Native American Pacific Islander (AANAPISI)	Los Angeles, California
Ames Research Center(ARC)	Supporting Organization	NASA Center	Moffett Field, California

Primary U.S. Work Locations
California

Project Website:

https://www.nasa.gov/strg#.VQb6T0jJzyE

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

University of Southern California (USC)

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Maja Mataric

Co-Investigator:

Elizabeth W Cha

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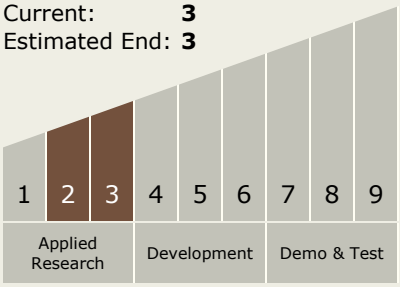
Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX04 Robotic Systems
  - TX04.4 Human-Robot Interaction
    - TX04.4.1 Multi-Modal and Proximate Interaction

Target Destinations

Earth, The Moon